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COLLECTING MICRO-ORGANISMS FROM THE ARCTIC ATMOSPHERE

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WITH FIELD NOTES AND MATERIAL

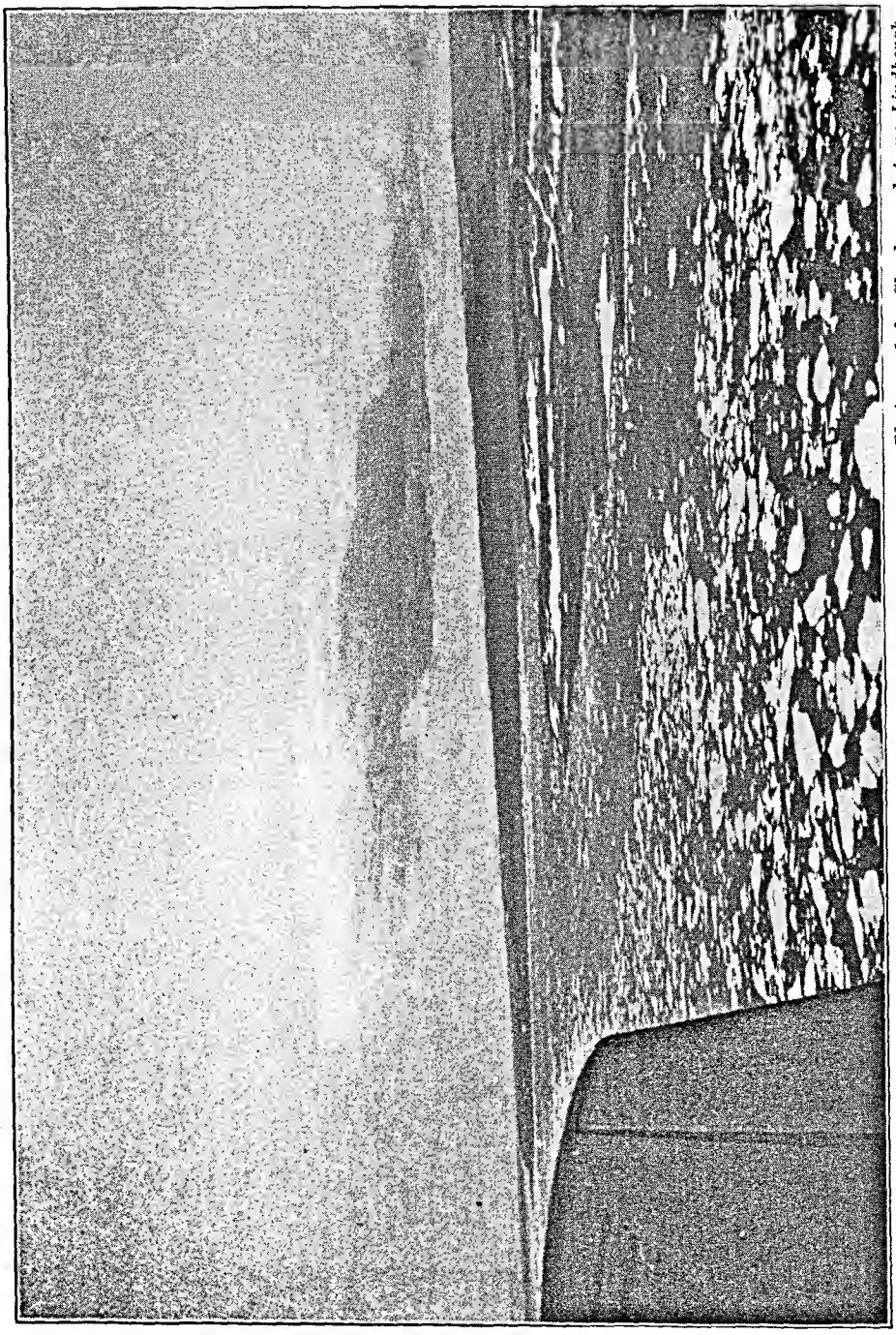
By CHARLES A. LINDBERGH

When the red-winged monoplane piloted by Charles A. Lindbergh soared away from Flushing Bay on July 9, 1933, bound for aerial exploration near the Arctic Circle, there began an unusual botanical collecting trip. Mrs. Lindbergh was prepared to fly the ship during intervals when her husband might be occupied with manipulation of an instrument new to transatlantic airplanes—so new, in fact, that it was completed just in time for the writer to carry it by plane from Washington to New York to be added to other scientific equipment which had been assembled for the expedition. With this new device, which, being untried, was noncommittally called the "sky hook," it was planned to make collections of microorganisms from the atmosphere along the course of flight. As an incidental feature of their aerial voyage, the two flyers were cooperating with the U. S. Department of Agriculture in its studies of the epidemiology of rusts and other plant diseases. It was also hoped that identification of materials collected at various altitudes between points on the course might contribute to our knowledge of the movement of air currents in northern regions.

History of Air-Content Studies

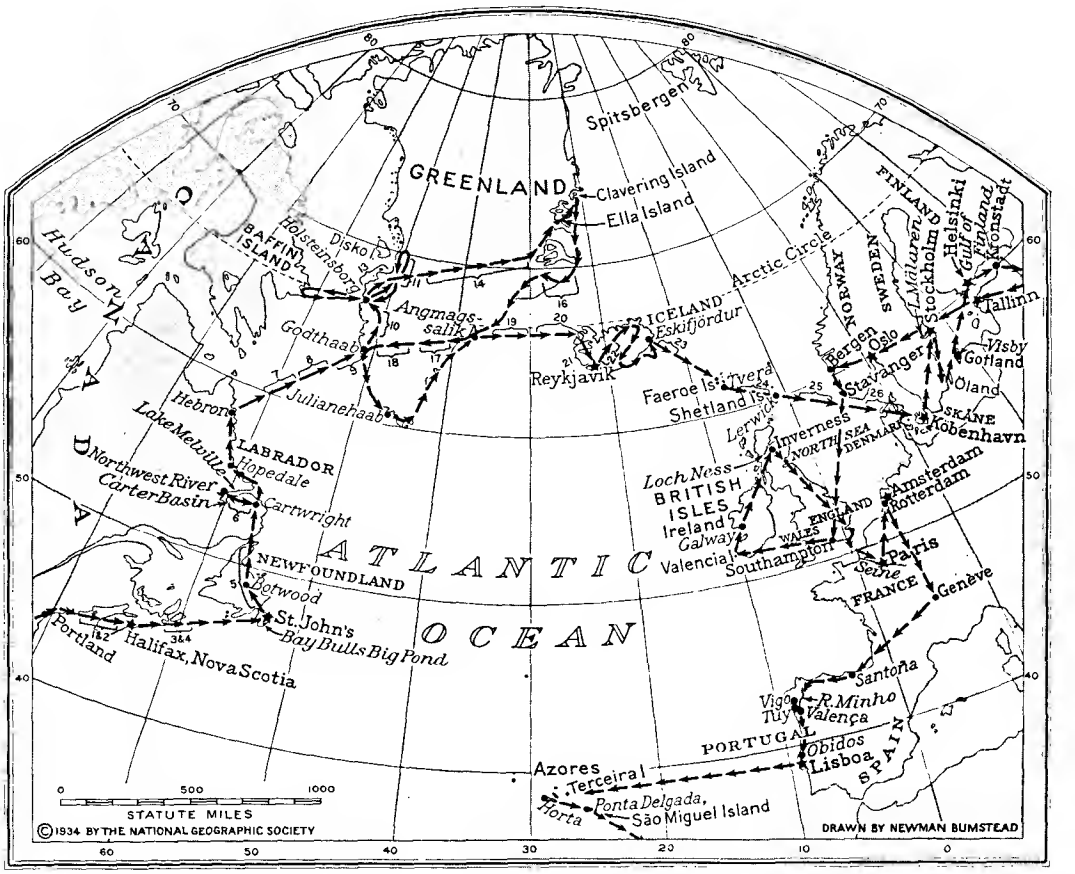
While it is generally known that bacteria, spores of higher fungi and pollen grains are present among dust particles in the atmosphere near the earth's surface, much detailed information of practical value remains to be revealed by further research. The aerial movement of pollen from certain flowering plants concerns the physician who deals with "hay fever" and related troubles. The plant pathologist and the medicopathologist are interested in obtaining facts concerning the part that air currents may play in disseminating reproductive bodies of organisms that cause specific diseases of plants and animals. Definite information of this sort is obviously an aid to a well-planned control program. As early as 1921 airplanes were used in making collections of rust spores as an aid to planning the barberry-eradication campaign for the control of stem rust of small grains. This work, by E. C. Stakman,[1] A. W. Henry, G. C. Curran, W. N. Christopher and pilots of the Army Air Corps, in the course of cooperative investigations of the U. S. Department of Agriculture and

[1] Stakman *et al.*, *Jour. Agr. Research*, 24, 1923.



Photograph by Charles and Anne Lindbergh

FIG. 1. LOOKING WEST FROM OVER SCORESBY SOUND



Courtesy of The National Geographic Society

FIG. 2. MAP SHOWING ROUTES FLOWN AND POINTS BETWEEN WHICH COLLECTIONS WERE MADE. NUMBERS INDICATE INDIVIDUAL COLLECTIONS AND REFER TO RECORDS SOME OF WHICH ARE GIVEN IN FIGURES 8 AND 9.

the University of Minnesota, stimulated other such studies. Similar rust spore collections were later obtained by plant pathologists in Canada, Germany and Russia.

Since the microscope first came into use, studies of micro-organisms in the atmosphere have been of absorbing interest to botanists and medical men. It was in 1830 that Ehrenberg[2] first published on microscopic objects which he found present in atmospheric dust. Later he reported finding infusoria in a dust sample collected by Darwin when on board the *Beagle* near Porto Praya. Perhaps inspired by the studies of Ehrenberg, Berkeley,[3] in 1857, writes in his "Introduction to Cryptogamic Botany":

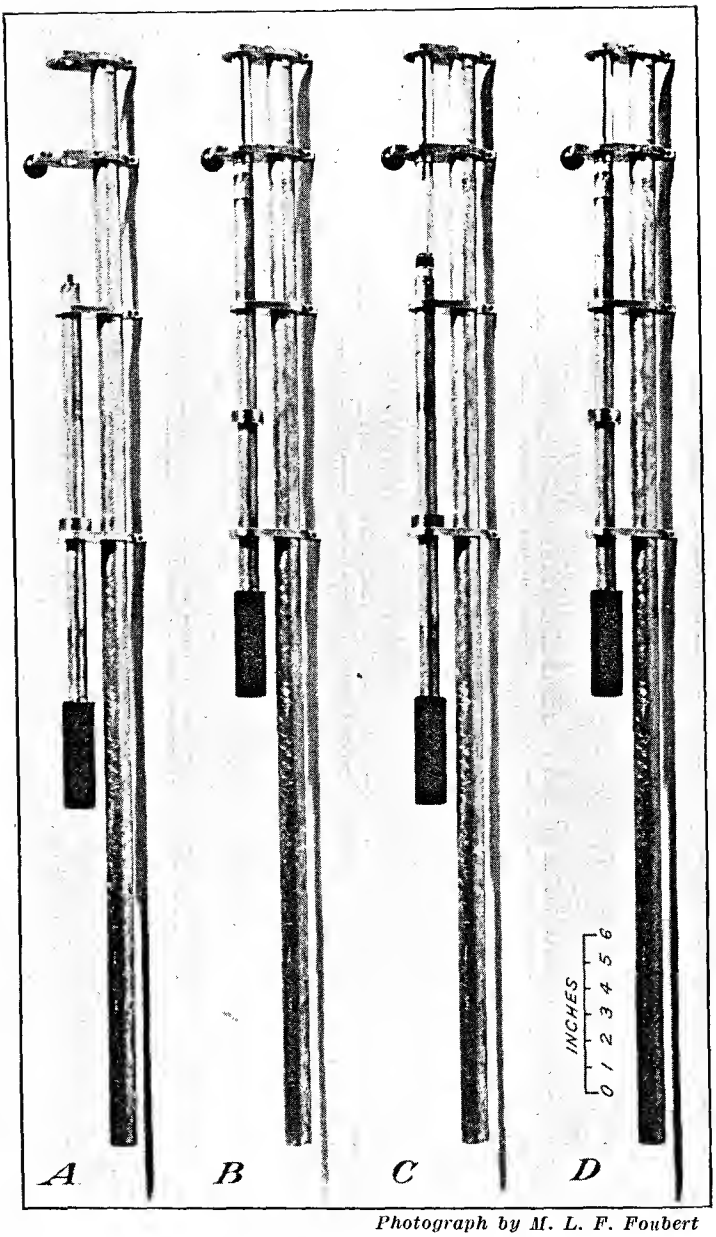
> Other spores are wafted about in the air, where they may remain for a greater or less period, till, obeying the natural laws of gravity, they descend in some distant regions. The trade winds, for instance, carry spores of Fungi mixed with their dust, which must have travelled thousands of miles before they are deposited.

Pasteur,[4] using an aspirator, conducted measured quantities of air through gun cotton, dissolved the cotton and examined the sediment with the microscope. By this means and his classical experiments involving the introduction of air from various sources into flasks of sterilized nutrient solution,

[2] Ehrenberg, *Ann. Phys. u. Chem.*, Jahrgang 1830, Viertes Stück, Vol. 17–18, pp. 477–514, 1829–30.

[3] Berkeley, "Introduction to Cryptogamic Botany," London, 1857, p. 258.

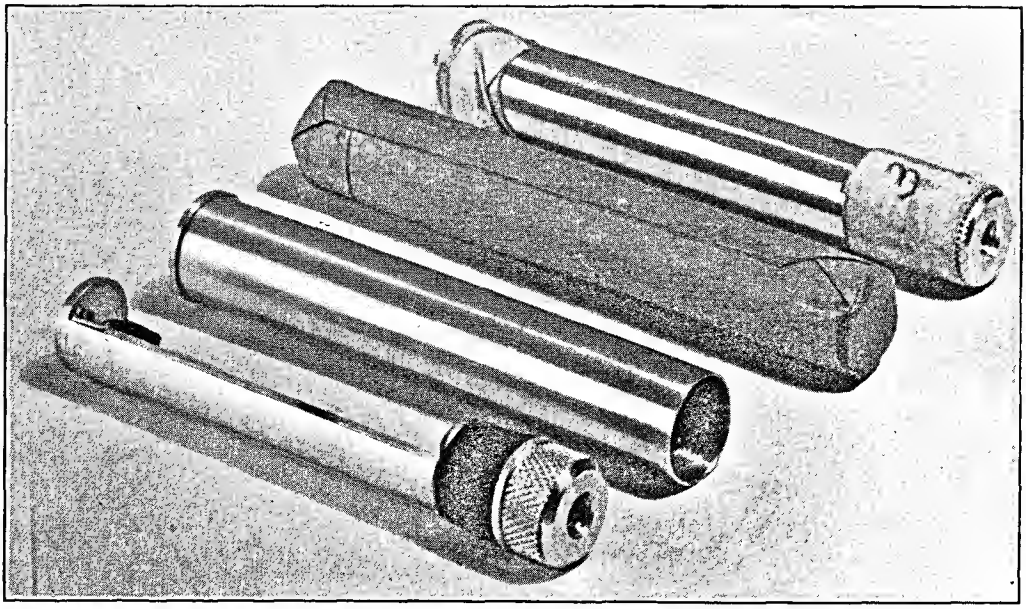
[4] Pasteur, *Compt. Rend. Acad. Sci. (Paris)*, 50, pp. 303–307, 1860.



Photograph by M. L. F. Foubert

FIG. 3. THE "SKY HOOK"

BUILT AROUND A PIECE OF ALUMINUM TUBING 1 INCH IN DIAMETER AND 42 INCHES IN LENGTH. WHEN IN USE, THE LOWER END OF THE TUBING SLIPS INTO A BRACKET PROVIDED FOR THE PURPOSE AT THE LEFT FRONT OF THE FORWARD COCKPIT. IN THIS POSITION, THE TUBING PROJECTS VERTICALLY TO A HEIGHT APPROXIMATELY 2 FEET ABOVE THE EDGE OF THE COCKPIT. THE UPPER END OF THE TUBING CARRIES TWO GUIDES INTO WHICH INTERCHANGEABLE ALUMINUM CARTRIDGES (FIG. 4) CAN BE SLIPPED AND FIRMLY FASTENED IN POSITION. AFTER THE UNEXPOSED CARTRIDGE IS ATTACHED TO THE HANDLE AND THIS IS CLAMPED INTO POSITION, THE ENTIRE OPERATION OF EXPOSING THE SLIDE AND RETURNING IT TO THE CONTAINER CAN BE CARRIED OUT BY MEANS OF AN ALUMINUM PULL-PUSH ROD OPERATED FROM BELOW, THUS AVOIDING DANGER OF CONTAMINATION FROM HANDS AND CLOTHING. ILLUSTRATION SHOWS: A, HANDLE READY TO RECEIVE CARTRIDGE; B, CARTRIDGE INSERTED AND READY TO BE PROJECTED INTO AIR STREAM; C, SLIDE PULLED INTO EXPOSURE POSITION; D, SLIDE RETURNED TO CYLINDER AFTER WHICH CARTRIDGE IS REMOVED AND SEALED.



Photograph by M. L. F. Foubert

FIG. 4. EACH SLIDE CONTAINER OR CARTRIDGE CONSISTS OF TWO MAJOR PIECES

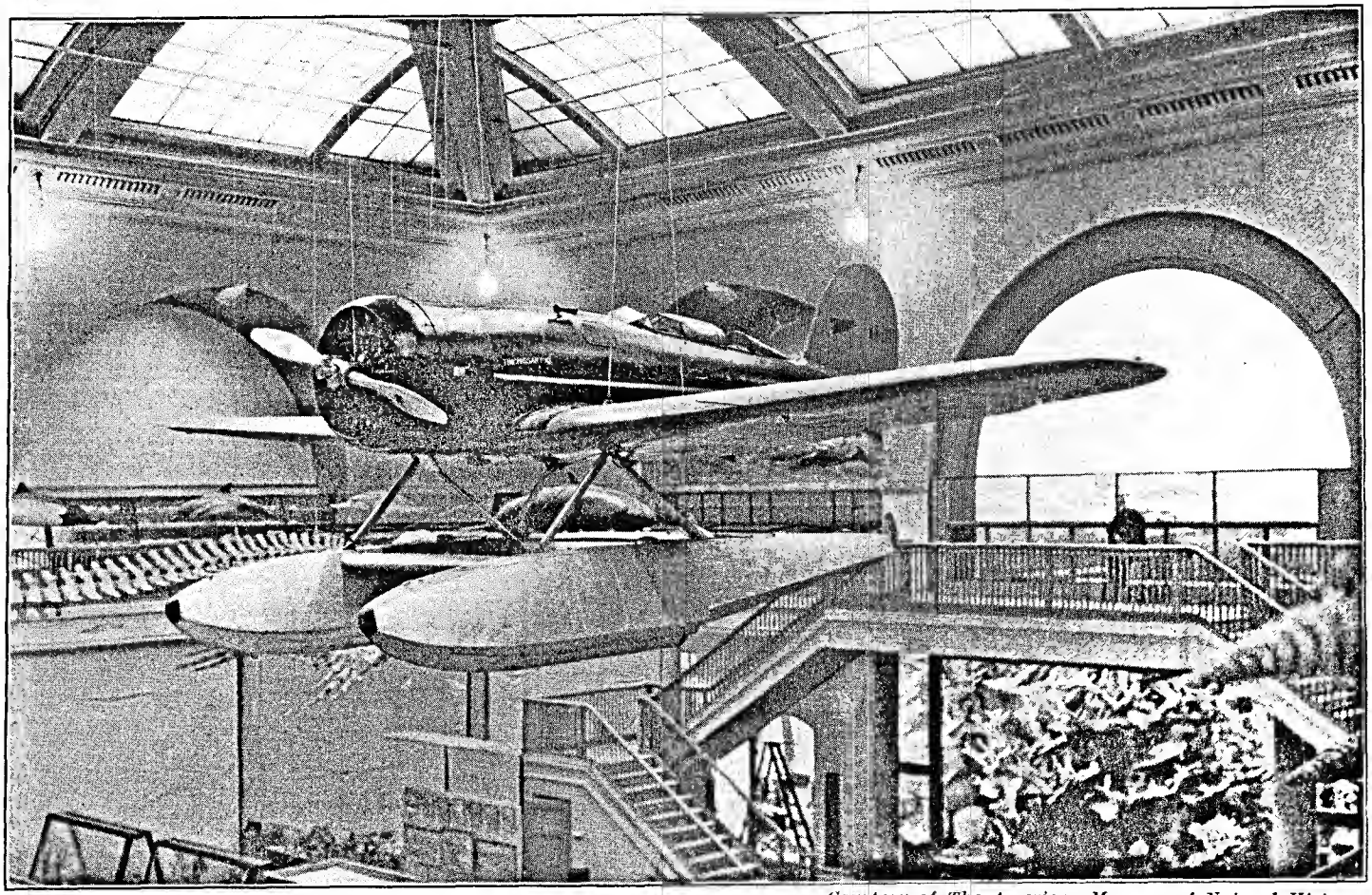
ONE OF THESE IS AN OUTER SHELL MADE FROM A SECTION OF THIN-WALLED ALUMINUM TUBING $4\frac{1}{8}$" LONG AND 11/16" INSIDE DIAMETER THAT IS PERMANENTLY SEALED AT ONE END AND OPEN AT THE OTHER. THE SECOND PART IS AN ALUMINUM ROD THAT IS CUT AWAY TO FORM A FLAT SURFACE THE LENGTH OF THE GLASS SLIDE. THE SLIDE IS FIRMLY ATTACHED TO THIS FLAT SURFACE BY MEANS OF A SCREW DEVICE. THIS INNER ALUMINUM BAR TERMINATES IN A CAP PIECE PROVIDED WITH A SEAL MADE OF A SHORT SECTION OF GUM-RUBBER TUBING HELD IN POSITION BY MACHINED POINTS. WHEN THE SLIDE IS IN THE CYLINDER, THE GUM RUBBER PROVIDES A SUFFICIENTLY TIGHT-FITTING CONNECTION TO PREVENT CONTAMINATION FROM THE OUTSIDE. WHEN THE BAR AND MOUNTED SLIDE HAVE BEEN WITHDRAWN TO THE EXPOSURE POSITION WITH THE PETROLATUM-COATED SURFACE FACING THE AIR STREAM, A CHECK RING ON THE CONTROL ROD STOPS THE WITHDRAWAL AT A POINT THAT LEAVES THE UPPER END OF THE SLIDE BAR SUPPORTED AGAINST THE LOWER RIM OF THE CYLINDRICAL CONTAINER. THE ILLUSTRATION SHOWS A SLIDE CARRYING BAR BEFORE BEING PLACED IN THE ADJACENT CYLINDER. BESIDE THESE IS A LOADED, PAPER-WRAPPED CYLINDER WHICH WAS CARRIED ON THE TRIP AND RETURNED UNUSED. AT THE EXTREME RIGHT IS AN EXPOSED CARTRIDGE AS RETURNED TO THE LABORATORY. IMMEDIATELY AFTER EXPOSURE THE CARTRIDGE WAS SEALED WITH ADHESIVE TAPE AND THE COLLECTION NUMBER WAS RECORDED. TAPE WAS APPLIED AT THE TOP TO PREVENT A POSSIBLE BREAKING AWAY OF THE CAP PIECE. THIS, HOWEVER, IN NO INSTANCE OCCURRED.

he proved that there are living bacteria and mold spores in the air and that the numbers vary considerably in different locations.

The many studies of air content conducted by nineteenth-century medical men in their efforts to combat epidemics of cholera and other diseases are reviewed by Cunningham[5] in a paper reporting his studies of air pollution, written while he served with the British Government as surgeon in India. Publication of this paper in 1873 stimulated bacteriologists in their studies of organisms present in the air around them.

Advances made in the development of aircraft early in the twentieth century made it possible to extend the scope of such investigations. All the earlier work was based on examination of air as

[5] Cunningham, "Microscopic Examinations of Air," Calcutta, 1873.



Courtesy of The American Museum of Natural History

FIG. 5. *TINGMISSARTOQ*

IN THE HALL OF OCEAN LIFE, THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY. HERE THE SHIP IS SURROUNDED BY NUMEROUS INTERESTING EXHIBITS FROM THE LINDBERGH ATLANTIC SURVEY FLIGHT.

found near the surface of the earth. Although Pasteur considered the possibility of conducting experiments from a hot-air balloon, he decided that the method presented too many difficulties, so carried his flasks up the Jura Mountains and the Montan Verte, where exposures were made at 850 and 2,000 meters above sea level. The previously mentioned studies of rust-spore movement by use of spore traps on airplanes suggested new possibilities for study of dissemination of organisms that cause plant diseases.

For example, the writer[6] has obtained pure cultures of numerous fungi from spores which he collected during training flights of the naval airship *Los Angeles* in January and April, 1932, and from airplanes in the course of investigations begun in 1931 by the U. S. Department of Agriculture with the cooperation of the Navy, Army and Coast Guard air-service units. The ease with which vigorous cultures of fungi have been grown from spores collected during these airplane flights, which were made at various altitudes over widely scattered coastal, desert, mountain, forest and agricultural areas of the United States, emphasizes the probability of long-distance movement of viable spores of certain saprophytic and parasitic organisms.

The day-by-day situation with regard to presence of micro-organisms at different levels in the atmosphere over a given territory was discussed by Proctor[7] before the American Academy of Arts and Sciences in April, 1934. In his summary of studies of 201 separate collections secured from 45 airplane flights made over Boston by the Meteorology Division of the Department of Aeronautical Engineering, Massachusetts Institute of Technology, he states: "Bacteria and molds were found above 19,600 feet, yeasts and pollens were found above 16,000 feet."

[6] Meier *et al.*, *Phytopathology*, 23, 1933.

[7] Proctor, *Proc. Amer. Acad. Arts and Sci.*, Vol. 69, No. 8, Aug., 1934 (Contrib. Dept. Biol. and Public Health, Mass. Inst. Technol., No. 29.)

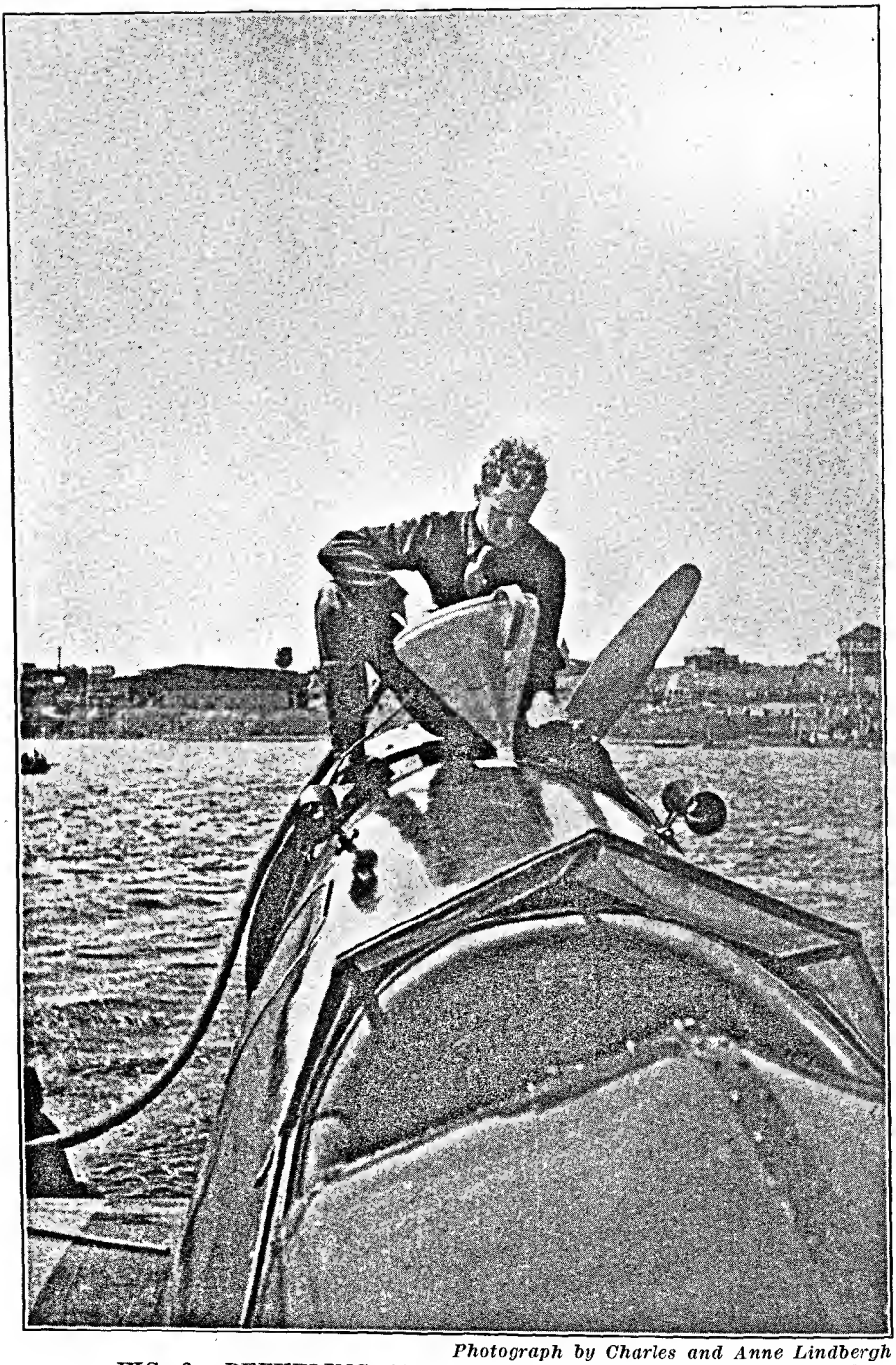
Significance of Northern Collections

Although, prior to the Lindbergh Atlantic Survey Flight, several investigators have used airplanes as an aid to study of micro-organisms present in air currents, such collections from the upper air have always been made over or near land in latitudes where numerous species of fungi growing on abundant local vegetation were constantly liberating spores. The opportunities for obtaining significant data on long-distance movements of spores and pollen would seem particularly good in the case of exposures made over water and ice of northern latitudes as compared with similar studies over land in the temperate zone, where the collector may be confused by much material originating from local sources (Fig. 1). The suitability of the course covered by *Tingmissartoq* in 1933 for studies of this kind is evident from the photographs and excellent descriptions given in Mrs. Lindbergh's[8] story of the flight and from the route as indicated on the map (Fig. 2).

The "Sky Hook"

The collecting device for this particular trip was designed by Colonel Lindbergh (Figs. 3 and 4) with several requirements in mind. It should be compact, light in weight and simple to operate. The containers enclosing the collecting medium must be constructed to prevent contamination before or after exposure. They must be sufficiently

[8] Lindbergh, Anne Morrow. Foreword by Charles A. Lindbergh, *Nat. Geog. Mag.*, 66, pp. 259–337, 1934. In this story, Mrs. Lindbergh tells of the christening of the plane: " 'Tingmissartoq!' Eskimos shouted when the monoplane circled overhead. So *Tingmissartoq* it became—'The one who flies like a big bird.' "



Photograph by Charles and Anne Lindbergh

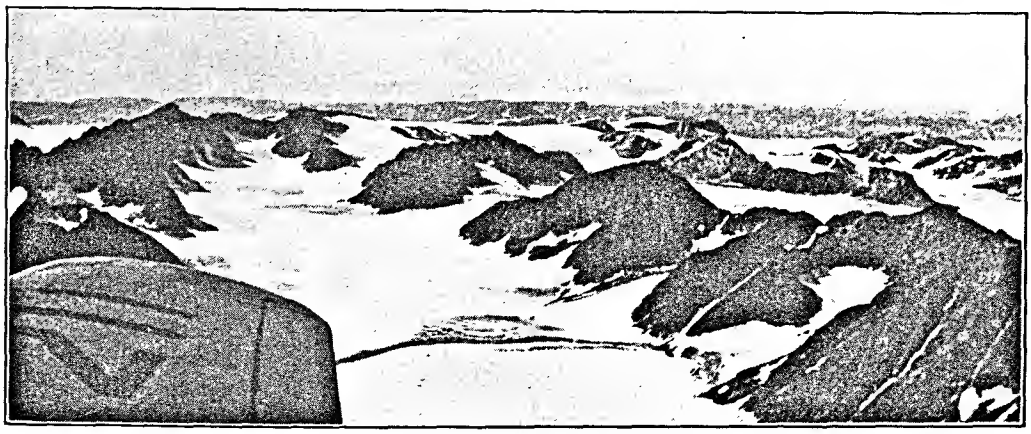
FIG. 6. REFUELING AT BOTWOOD, NEWFOUNDLAND

strong to stand possible rough handling without breakage. It was, of course, also important that the collecting medium used be such that material would remain in condition for examination some weeks or months after the sample was taken. Colonel Lindbergh's knowledge of pure-culture technique made him thoroughly aware of the necessity of developing a trap that could be used with minimum danger of error resulting from contact with dust in the cockpit. From discussion of these various requirements a plan was evolved for a modification of the oiled microscope slide trap. Glass slides with oiled surfaces have frequently been utilized in aeroscopes by investigators working on the ground, from roofs of buildings or from aircraft. After a design had been developed, the services of the American Instrument Company, of Washington, D. C., were enlisted. The personal interest taken in the project by both officers and employees of this company made possible "overnight" construction of the "Sky Hook" and fifty cartridges.

In preparation for these northern flights, the cartridges or slide containers (Fig. 4), after having been thoroughly cleaned, were loaded in the still air of a culture room. After a mount carrying the petrolatum-coated glass slide had been inserted in each cylinder, with the gum rubber washer serving as a seal, a band of adhesive tape was applied. This served to prevent accidental opening. The surface of the entire cartridge and seal was then cleaned by moistening with alcohol, followed by thorough rubbing with sterile gauze, after which the cartridge was wrapped in clean sterile paper for protection until used.

Contamination from the Airplane Unlikely

The low-winged monoplane *Tingmissartoq* is an exceedingly trim ship, as is evident to those who have viewed her graceful lines as she hangs suspended, a central figure of the Lindbergh collection in the American Museum of Natural History (Fig. 5). Immediately forward and below the cockpit windshield is nothing but the smooth skin of the fuselage. The exhaust is carried away from the motor through a short stack below the fuselage. Directly ahead of the spore trap when in exposure position were the propeller tips only. In view of the fact that the writer frequently has found it possible to



Photograph by Charles and Anne Lindbergh. Used by special permission. Copyright, National Geographic Magazine

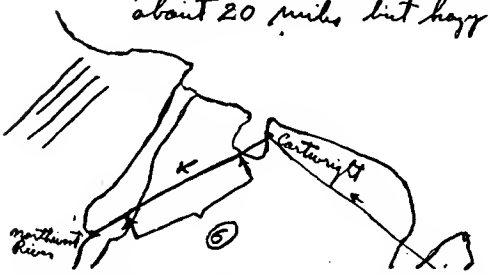
FIG. 7. BLACK MOUNTAINS PUSH JAGGED POINTS THROUGH THE SNOW

A tip of the wing shows in the picture as the plane skirts the ice cap southward from Clavering Island to Angmagssalik.

Azimuths are given in degrees from true north and indicate direction from which wind comes 11

No. ⑤ – will supply data later.

No. ⑥ – July 17 - 3:37 to 4:47 (Local time). Wind (from) 245° (True) about 10 M.P.H. Average altitude 4000 ft (2000 to 5500) Temp +12°C Air speed 115 M.P.H.. Sky 7/10 to 10/10 overcast at about 8000 ft. Visibility about 20 miles but hazy.



No. 7 July 22. 17:24 G.M.T. to 18:24. Wind 270° about 15 Miles. Average alt. – 2500 ft. Temp. +12°C Air speed 110. Flying over low fog. (Top about 1000 ft.) Clear above fog. ——— . Visibility about 100 miles. Apparently no rain for several days.

No. 8. July 22. 18:42 G.M.T. to 19:27. Wind 270° about 20 miles. Average alt. – 3000 ft. Temp +11°C. Air speed 110. Flying over low fog (Top about 1000 ft.). Clear and unlimited above fog.

No. 9 July 22. – 19:45 to 20:45 Wind 270° about 15 M.P.H. Average alt. 3000 ft. Temp +11°C Air speed 110. No fog. Clear and unlimited.

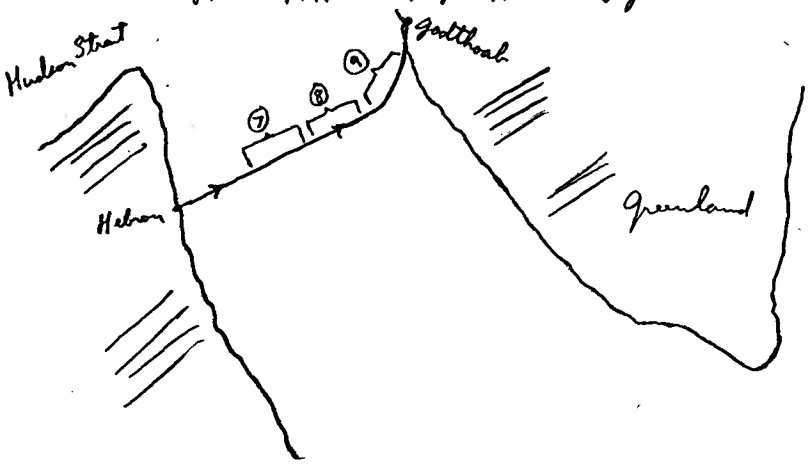


FIG. 8. PHOTOGRAPH OF ORIGINAL PENCIL NOTES SENT IN BY COLONEL LINDBERGH WITH THE SLIDE CONTAINERS. SIMILAR FREE-HAND MAPS WERE PROVIDED FOR EACH SLIDE DESCRIPTION.

No (13) Aug 4, 1933 - 15:36 to 16:21 G.M.S. Wind 90° about 5 mils. Average alt = 5000 ft. - Temp. = 0°C. Air speed 110 mils Sky 8/10 overcast at 10,000 ft. Visibility unlimited. Lowest alt. = 4500.

No (14) (Cotton) Aug 4, 1933 - 17:11 to 20:18 G.M.S. - Wind 180° about 40 mils at start of exposure. No wind at end of exposure. - Maximum alt = 12,500 ft. average = 10,000 Temp. minimum = -12°C. average = -9°C. Air speed 110 mils Completely overcast at 10,000 to 15,000 ft. (Due to the comparatively low temperature the rubber cork came out while the cylinder was being removed and the lower part of the slide was exposed in the cockpit for a fraction of a second. This may be sufficient to cause an erroneous positive result)

No. (15) Aug 6, 1933 - 12:55 G.M.S. to 13:40. Wind calm except in fjords. Average alt - 3,000 ft. - Temp. = +6°C. Air sp. 115 mils. Sky clear and unlimited visibility.

No (16) Aug. 6 - 14:40 to 15:40. Wind calm. Sky clear and unlimited visibility. Average alt 7,000 ft. Temp. = -1°C. Air speed 110 mils

No (17) Aug 8 - 16:22 to 17:22. Wind 45° 15 mils (From balloon observation) Sky less than 1/10 overcast (Cirrus) visibility unlimited. Average alt. 8,000 ft Av. temp. = -8°C. Last 20 minutes completely overcast at 9000 ft (Plane flying below clouds wind shifted to North West about 20 mils.

FIG. 9. PHOTOGRAPH FROM ORIGINAL PENCIL NOTES SENT IN BY COLONEL LINDBERGH WITH THE SLIDE CONTAINERS. NUMBERS REFER TO EXPOSURES INDICATED ON THE MAP (FIG. 2).

secure clean slides during exposures at high altitudes, made by projecting the collecting device over the side of the rear cockpit of a biplane with the many surfaces ahead to collect dust when the plane is on the ground, it is evident that the rush of air when in flight quickly and thoroughly removes dust particles from these surfaces.

This particular ship had no such surfaces ahead. Being a seaplane, refueling was carried on under conditions relatively free from dust stirred up by surface winds (Fig. 6). Moreover, the speed of flight and consequent effectiveness of air washing were greater by 30 m.p.h. than those obtained in biplanes ordinarily used by the writer.

Twenty-Six Slides Exposed

Twenty-six collections were made during the period from July 11 to August 26 on flights between North Haven, Maine, and Copenhagen, Denmark. Many of these were obtained while flying over vast expanses of water, ice and bleak mountainous country (Fig. 7). With the expectation that the atmosphere of the far north would be thinly populated with organisms, if any at all were present, long exposures, thirty minutes to sixty minutes, were made. In previous work in southern latitudes exposures of three to ten minutes at air speeds ranging from eighty to one hundred eighty miles per hour have been found by the writer to give good results. The territory covered is indicated on the map shown in Fig. 2. Field notes by Colonel Lindbergh, similar to those shown in Figs. 8, 9 and 10, give circumstances surrounding each collection, making possible interpretation of results. It must be remembered, however, that frequently several days intervened between collections. During these periods the botanical relationships were, of course, changing as the season advanced. Wind direction and velocities varied at times when different collections were made. Moreover, unknown air movements and atmospheric changes were taking place between collections. These factors must all be considered in attempts at correlating results.

In an account of the work sent from Reykjavik Colonel Lindbergh wrote:

> Before opening for exposure, all the cylinders were left in the air stream from three to five minutes. They were all closed while still in position and were sealed with adhesive tape without again being opened. It was not possible, however, to avoid sometimes touching the knurled end, and the tape, of course, was exposed to the turbulent air in the cockpit.

Hence, at his suggestion, before the slides were removed for laboratory examination, the exterior of the cylinders, including the area covered by the tape, was flamed to destroy any microscopic objects which might have adhered.

Examination of Slides

Following their return to Washington, the cartridges were left unopened until each slide could be studied. In preparation for examination, the cylinder was flamed, the slide was removed in the still air of a culture chamber, and a permanent mount was made. This was done by adding a small quantity of filtered lactophenol to the exposed surface, covering the preparation with a flamed clean strip of No. 1 cover glass, and, finally, after the preparation had been allowed to rest several days in a desiccator, sealing it with lanolin cement. Counts were then made over a five square centimeter area while traversing the slide laterally with a three millimeter dry objective and 15x ocular, and photographs were taken of distinctive spores or pollen grains with this same lens combination. In some instances the camera lucida was employed for the work of recording. The position of different objects was recorded on the mechanical stage, and descriptive notes, including ocular micrometer measurements, were made of distinctive types.

Check Slides

Six slide containers, returned unused after having been carried throughout the trip, were employed as checks. Careful microscopic examination of the slides within demonstrated these to be free from spores and pollen grains.

Numerous examinations of petrolatum from the lot used in preparing the slides for the trip, likewise gave confidence in results obtained.

Discussion of Results

In these collections are found spores of fungi, pollen grains and fragments of

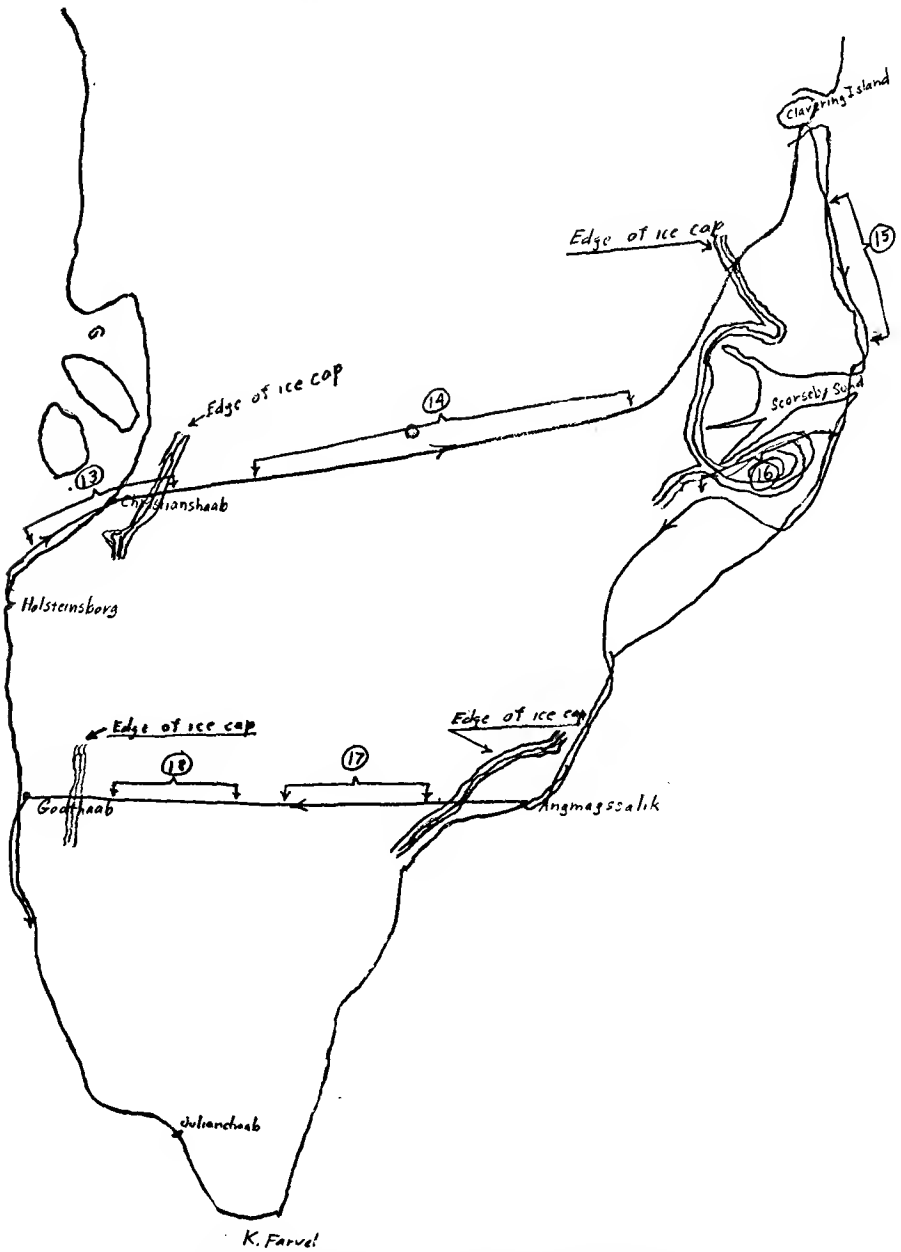
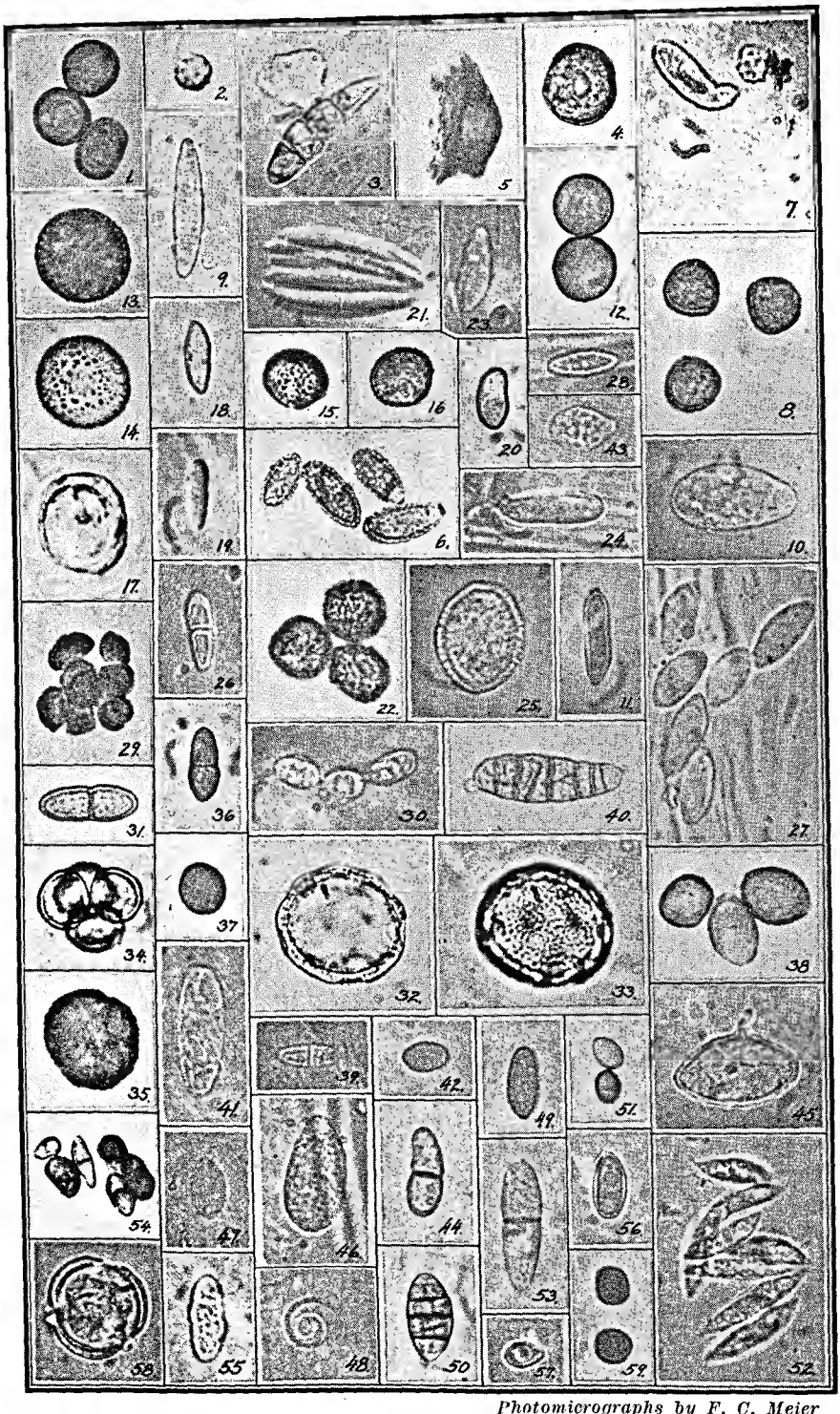


FIG. 10. ROUTE MAPS DRAWN IN THE FIELD BY COLONEL LINDBERGH SERVED TO MARK POINTS BETWEEN WHICH COLLECTIONS WERE MADE.

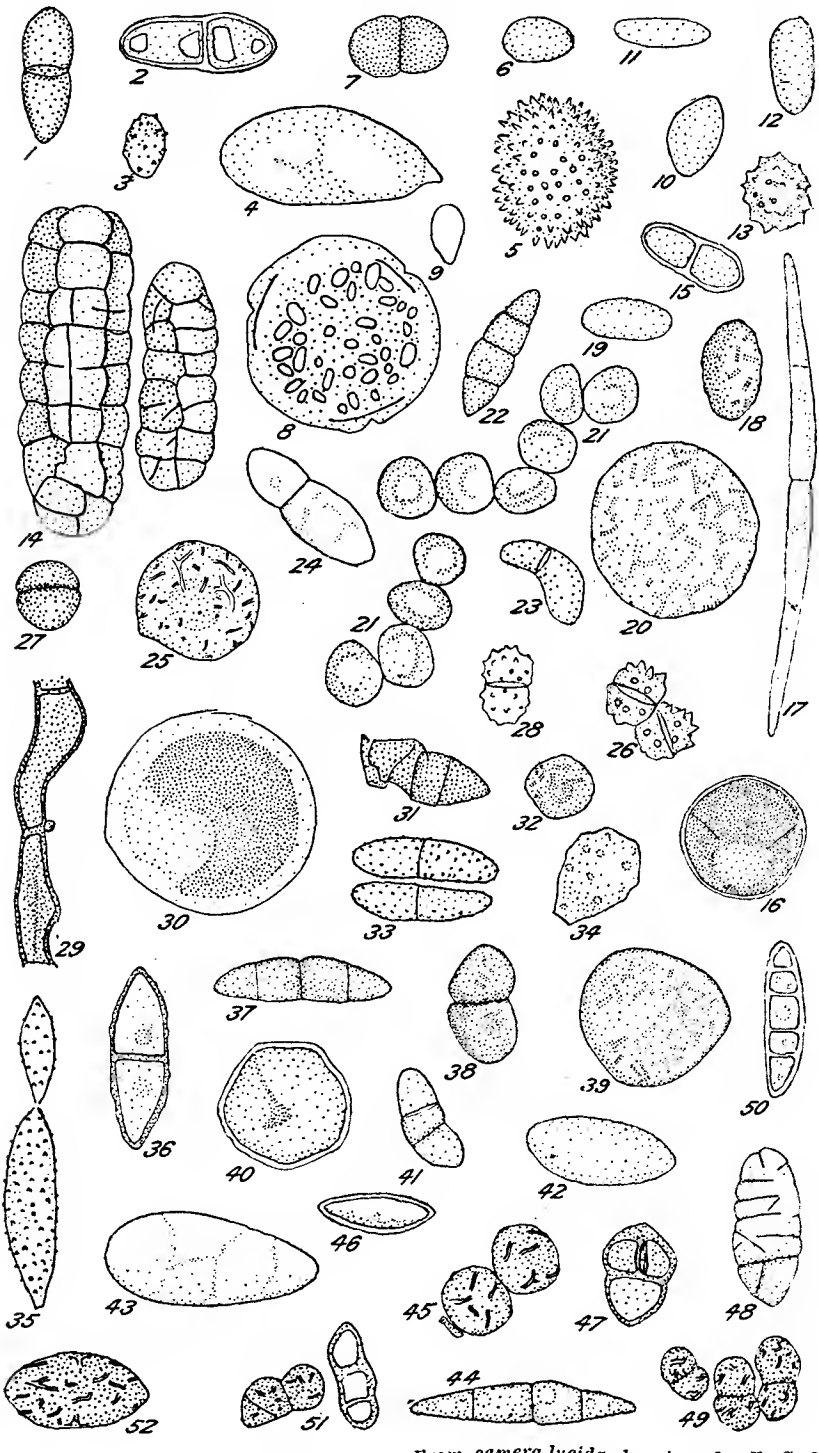
fungous hyphae. In some instances the asci of certain fungi, apparently carried up just before discharge of spores, were caught, the spores being spattered about by the impact. In addition were found unicellular algae, fragments of filamentous algae and insect wings, diatoms, objects tentatively identified as sponge spicules, volcanic ash and glass, and other microscopic débris of the air.

It is not the purpose of this paper to give detailed descriptions of the fungous spores caught. Instead, descriptions, tentative identifications and correlation of information obtained from different slides are reserved for a later paper. The two figures 11 and 12 will, however, serve to give an idea of the variety of material collected over Davis Strait and Northeastern Greenland.



Photomicrographs by F. C. Meier

FIG. 11. SOME OF THE MORE CONSPICUOUS OBJECTS FOUND ON SLIDE 9. X 660. (SEE FIGS. 2 AND 8.)



From camera-lucida drawings by F. C. Meier

FIG. 12. TYPES OF OBJECTS TRAPPED ABOVE THE ARCTIC CIRCLE ON SLIDE 15. X 970. (SEE FIGS. 2 AND 9.)

Fig. 12 is the result of a careful examination of five square centimeters surface of slide 15. This slide was exposed on August 6 for forty minutes at an average altitude of 3,000 feet above sea level over the coast of Greenland between Scoresby Sound and Clavering Island, north of 70 degrees latitude and well above the Arctic Circle. Wind was from the west, about 15 m.p.h. The complete data for this exposure are given in Figures 9 and 10. Fifty-three different types of objects were found on this slide, duplication of some bringing the total number up to one hundred and ninety-three. A similar area on slide 9, exposed over Davis Strait sixteen days earlier than slide 15, was found to contain approximately 70 different objects and a total of 238 (Fig. 11). This slide was exposed for 1 hour on July 22 at an average altitude of 3,000 feet as the plane approached Godthaab, Greenland. Wind was from the west about 15 m.p.h. (Fig. 8). Nearest land to windward was Labrador.

Critical study of such slides must obviously be limited to objects that have sufficient size and character to make possible their identification. Often in the case of fungous spores, it is impossible to establish identity. In other instances, one can at least feel sure of the genus. Often the presence of a bit of mycelium or relationship of similar spores on the slide gives a clue. Plant pathologists, mycologists and other botanists acquainted with pollens will recognize certain familiar types among those shown on Figures 11 and 12. Among the spores on those two slides are forms which have been tentatively assigned to various genera, among them being Macrosporium, Cladosporium, Leptosphaeria, Mycosphaerella, Trichothecium, Helicosporium, Uromyces, Camarosporium and Venturia. It is hoped that with the aid of specialists on different groups of fungi, lichens, mosses and flowering plants the number of positive identifications may be increased.

Writing in *Mycologia* early in 1934, Jakob E. Lange[9] says:

> But stronger and more lasting than any other impression is the evidence of the wonderful cosmopolitanism of the Agarics. When you have once found, in a Danish Sphagnum-bog, a few specimens of the "new" species *Stropharia psathyroides* Lange, it gives you a shock to meet with the very same plant in a bog in Oregon, near the Pacific Coast—and only an hour later to come upon *Lepiota cygnea* Lange, of which the only known specimens were hitherto those gathered in 1925, a few miles from my Danish home!
>
> Who can trace the aerial course of the spore?

This Lindbergh collection of micro-organisms from the atmosphere is the first of its kind to give concrete evidence of the part played by air currents in distribution of fungi between northern lands. The slides show certain spore types to be abundant over Maine and Labrador and present in diminishing numbers as collections progressed to leeward over Davis Strait, the great ice cap of Greenland and Denmark Strait. Some of the spores of fungi caught at different points show definite evidence of having been alive when trapped, for they started to send out germ tubes in the unfavorable petrolatum medium. While, as would be expected, the collections show this northern air to be more thinly populated with micro-organisms than that over the continents in more temperate regions, it must be realized that, when one viable spore is precipitated to water or vegetation under surroundings capable of sustaining growth, reproduction may be very rapid. The potentialities of world-wide distribution of spores of fungi and other organisms caught up and carried abroad by transcontinental winds may be of tremendous economic consequence.

[9] Lange, *Mycologia*, 226, pp. 1–12, 1934.